Adaptation of face recognition systems to operating conditions using Simulink

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Abstract. The process of adaptation of face recognition systems to operating conditions, with respect to technical constraints, and assessment of the complexity of implementation is considered. The Simulink-based library for building models of software complexes is developed.The use of the library is considered to determine the structure of the system, the composition of the blocks and the adjustment of their parameters.

Keywords: the face recognition, object-oriented modeling, simulink.

1. Introduction

In the last two decades, the appeal to the topic of face recognition systems in mass media has become increasingly frequent. However, in the academic world, from the middle of 2016, the interest in the problem began to decline. Only on IEEE Explore [1] in 2005 about 2500 articles were published, in 2015 – 6 000, in 2016 – 6 000, with the most part published in the first half of the year. And in 2017 only 4200 articles on the recognition of faces were published.

The wide popularity of software for searching for individuals began with the presentation of the algorithm NTechLab in 2015, after which neural networks and personality recognition became inextricably linked, and new publications are usually devoted to neural networks. The described systems cope with difficult recognition conditions: almost any turn of the head, facial expressions, type of illumination is available to them. It seems that the problem was solved and now it is just needed to install the cameras and connect them to the recognition systems. However, the cost of one such camera can be about 60 000 of rubles, and the payment for each year of service will also be charged [2].

There are other obstacles to the massive implementation of such systems: the complexity of integration, the high load on the data transmission channels, the cost of buying and maintaining servers, the inability to work offline. It is also worth noting that a "bad" facial base is a hindrance to training a neural network [3]. It is clearly seen in the example of FindFace, a program for finding individuals in the social network "Vkontakte", the accuracy of which is about 70%.

Today it is possible to say that universal recognition systems have been created, but universality must be understood strictly in the sense of "independence from factors hampering recognition". In this case, there are problems for which the use of universal systems is redundant, for example, identification of persons in access control systems. There are also situations in which the use of non-autonomous systems is impossible: identification of a person by a sketch in the absence of a network signal. In addition, there is a need for pre-processing of data before use in a neural network, this problem is also not sufficiently widely represented in the literature.

Three groups of modern tools are used to model face recognition systems: the software development environment, graphic environments of simulation modeling, and specialized software. At the moment, the most convenient tools are graphical environments for simulation modeling [4], since for the improvement of face recognition systems it is advisable to present them in the form of graphic models consisting of blocks connected by data transmission channels. Such a view helps the inventor to see the problem in terms of supersystems and subsystems, to work at the selected level of detail, to see ways for improvement not only in algorithmic implementation, but also in the structure of the system.

The use of Simulink will be considered to improve the accuracy of recognition by selection the optimal structure of the system and more precise adjustment of its parameters.

1. Design of an elementary face recognition system

Quite often in face recognition problems, different categories of images are used, represented by the corresponding vectors of the original features. Thus, for example, the application of a discrete Fourier transform allows to obtain spatial-spectral invariant faces, and a discrete cosine transform allows to represent a small number of features and to be invariant with respect to turning the head to the left or to the right.

Two-dimensional Discrete Fourier Transform (DFT) and Discrete Cosine Transform (DCT) make it possible to obtain recognition results with high accuracy, which can be further enhanced by the correct parameters selection of the methods. To estimate the dependence of the recognition accuracy on the number of selected features p, we compile the Simulink model presented in Figure 1.

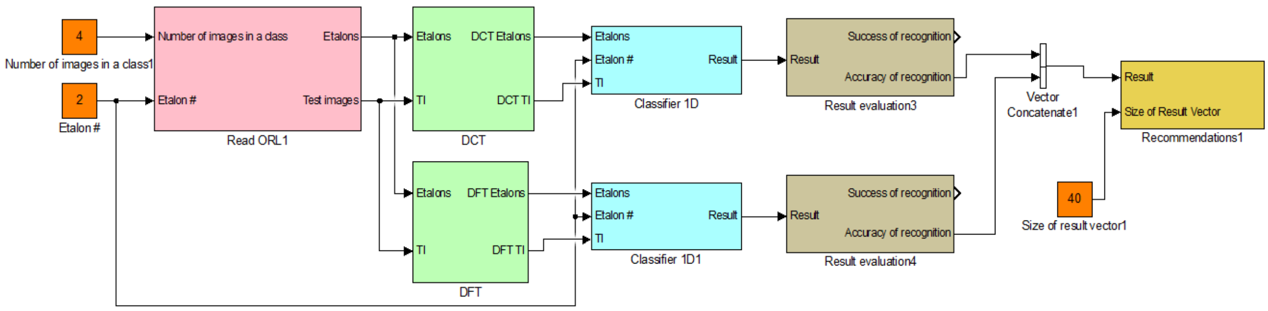

Figure 1. Parallel system two-dimensional DFT and DCT.

Here in the parallel Face Recognition Sysytem (FaReS) are collected 2 branches, which are the simplest recognition systems, with two-dimensional DCT or DFT as an extractor, respectively.

Facial images database ORL was chosen for the experiments, since it presents factors that complicate the process of recognition and selection of the system operation parameters: head rotations in space, facial expressions change, contrast of images and background brightness, presence and absence of glasses.

The database of images of individuals consists of 40 classes, 10 images in each class represent one person. In the experiment below, 2 images were selected as etalon images. The value of the parameter p varied from 5 to 30 in steps of 1. Ten experiments were performed for each p, and the number of the etalon image was changed.

The experimental results allowed to determine that the best values of the parameters were p equal to 10 for DCT and p equal to 20 for DFT.

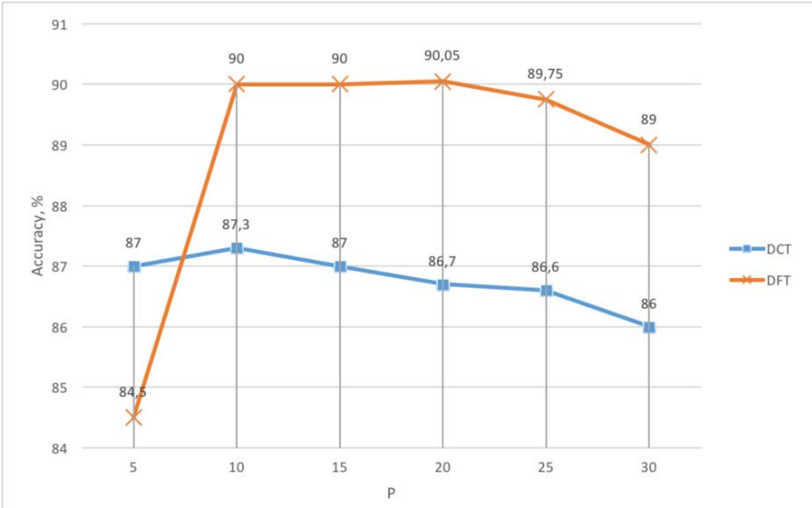

Figure 2. Dependence of recognition accuracy of DFT, DCT on the number of selected features *p*.

2. Comparative analysis of face recognition systems using Simulink

Simulink's capabilities allow for a comparative analysis of face recognition systems in visual form. It is necessary to arrange the compared systems as separate parallel branches and combine them at the output with the evaluation block.

System consisting of 5 subsystems is shown in Figure 3, each of which is an independent, simple recognition system. As branches, there may be more complex models, which in turn may have a parallel, cascade or combined structure.

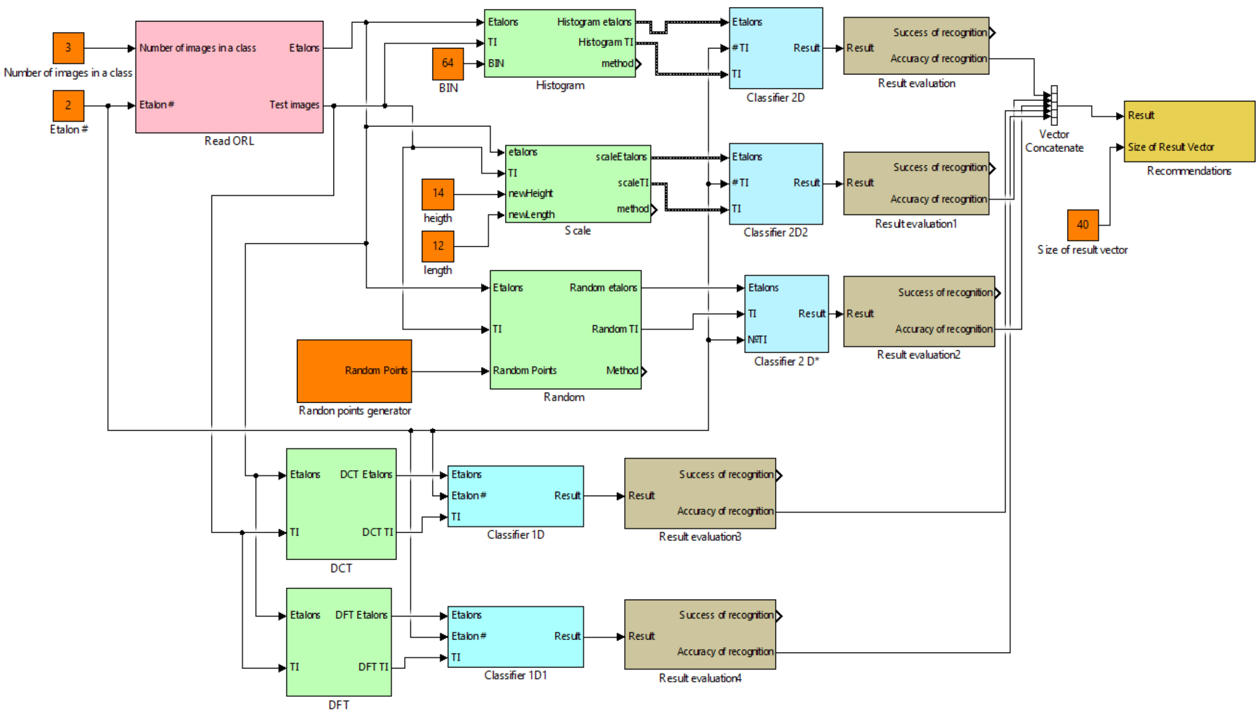

Figure 3. Comparative analysis of several systems in Simulink.

The results of the analysis are presented in Table 1, it is evident that when using the test images with the number 9, the accuracy has increased for all the methods considered, and therefore it is appropriate to use them as etalon in the future.

Table 1. Dependence of the recognition results on the selection of the test image, in the experiment 4 etalon images were used.

Method	**Number of a test image**									
	1	2	3	4	5	6	7	8	**9**	10
Histogram	80	80	77,5	85	90	97,5	85	93,5	**95**	92,5
Scale	37,5	37,5	35	22,5	37,5	37,5	32,5	37,5	**47,5**	27,5
Random	82,5	82,5	85	85	85	85	82,5	82,5	**87,5**	80
DCT	92,5	92,5	95	92,5	92,5	90	85	95	**90**	77,5
DFT	90	95	92,5	85	92,5	90	87,5	92,5	**100**	90

By combining 5 systems into one, it is possible to reduce the number of experiments, which is a significant advantage of Simulink when choosing the environment for modeling FaReS. You can save the model for further work, modify the branches and adjust the parameters of the blocks.

3. Additional ways to improve the accuracy of face recognition systems

The construction of parallel structures in Simulink can be used not only for comparative analysis, but also for increasing the accuracy of recognition. The system presented in Figure 3 was modified by adding comparators, here at the output of the classifiers are the results of recognition using one of the simple extraction methods (Histogram - H, Scale - S, Random - R, DCT - C, DFT - F), and the comparators based on the majority vote principle take the final decision on the class number of the test image.

By combining simple methods on triples, for example, RHS (Random-Histogram-Scale), 10 new systems were gotten. To compare the results of their work in Simulink, it is enough to conduct just one experiment, the model of which is shown in Fig. 4.

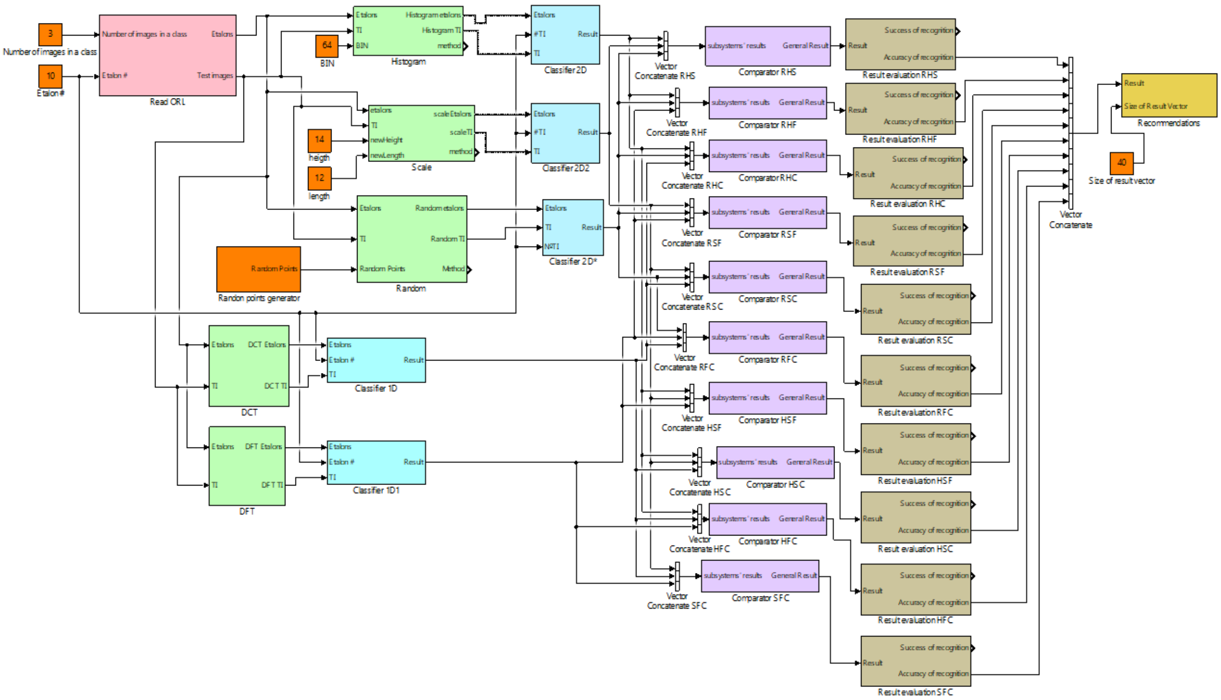

Figure 4. Comparison of combinations of methods of feature extraction.

Even taking into account the fact that the simplest face recognition systems were used as parallel branches, the diagram presented in Figure 4 is difficult to perceive, nevertheless the description of the experiment in the form of a set of graphic elements is more visual and convenient in comparison with its textual description.

The results of the experiment are presented in Table 2. The last line represents the results of the accuracy of the systems.

Table 2. Variants of a combination of features extraction methods.

RHS	RHF	RHC	RSF	RSC	RFC	HSF	HSC	HFC	SFC
0,78	0,75	0,8	0,79	0,8	0,8	0,81	0,82	0,83	0,85

The experiment shows that it is possible to achieve an increase in accuracy not only by changing the algorithms and adjusting the parameters, but also by changing the architecture of the model of FaReS. At the same time, it is quite difficult to operate with the architecture of the model even having a graphic representation in the form of blocks and connections between them. Using Simulink's built-in capabilities, we simplified graphical representation of the system by combining some of the blocks into subsystems, while the original blocks will not be affected and will be available for modification and subsequent use. The result of grouping the blocks into subsystems is shown in Figure 5.

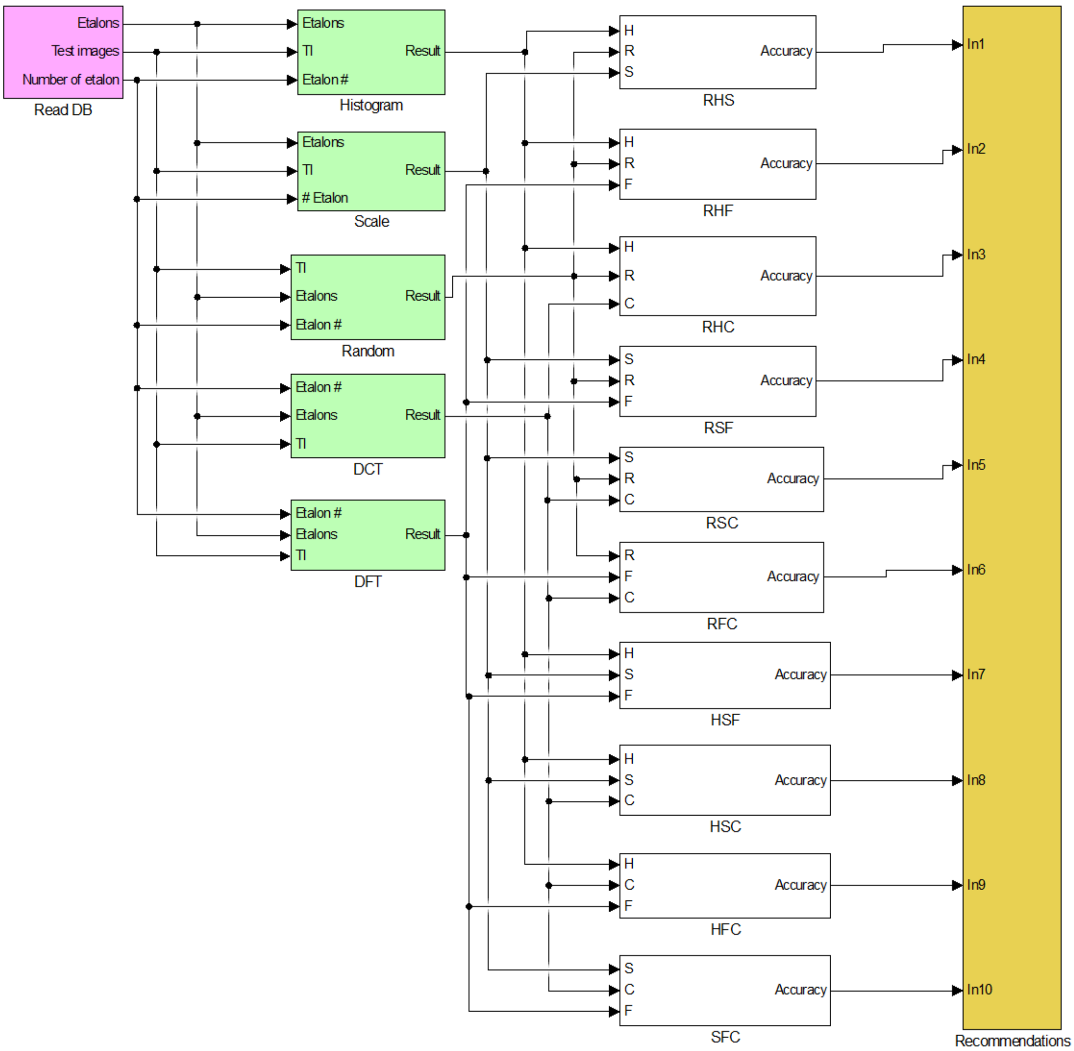

Figure 5. The result of grouping blocks into subsystems.

The resulting model allows to work with the system at a higher level of abstraction, with the deployment of individual blocks we can work separately with each of them without being distracted by the top-level context.

4. Analysis of the results

The analysis of the application of the custom Simulink block library for solving problems of applied face biometrics showed that Simulink is suitable for modeling face image retrieval systems, since it does not require high user skills in programming when creating new blocks, automatically supports new operating systems, ensures compatibility of custom modules with an extensive set of ready-made solutions from MathWorks, and also allows to work with data using a matrix representation. Being a graphical development environment, Simulink allows solving the problems of improving FaReS with information at the level of the blocks and the connections between them, which increases the number of solutions by adding structural modifications to the parameter setting and working with the extraction and classification algorithms. Simulink is a set of professional tools for research activities, but in addition to its direct purpose, it is also possible to use the developed library of blocks for modeling FaReS as a support for a laboratory workshop on subjects related to image processing and recognition.

A serious limitation of the use of Simulink for working with face images databases is the slow work with loops, as well as the laboriousness of setting up links between blocks in cases where the size of the input and output data can vary depending on the model parameters. Possible alternatives to Simulink may be LabView or high-level programming languages with specialized mathematical packages and visualization tools. At the same time, the proposed solutions also have their drawbacks, LabView does not allow full-fledged operation of data in a matrix form. Of the high-level languages, Python is the optimal solution because of its low level of needed programming skill, a wide range of mathematical libraries (it's especially worth noting Theano for working with matrix algebra), but the only ready-made graphical modeling solution is JModelica, which requires a description of the structure of the system in text form.

5. Conclusion

At the moment, Simulink is the best tool for modeling FaReS. However, the standard library does not allow you to configure the number of classes and images in it, which is very important for modeling and working with large databases. To simulate FaReS, Simulink's standard capabilities are not enough, so for the above experiments it was necessary to develop custom Simulink block library, where each FaReS module is encapsulated in a separate Simulink block, then links are made between the blocks, which allows describing FaReS as directed graphs. Such a presentation allowed to abstract from the program implementation of specific methods and work directly with the structure of the system and the selection of its parameters.

6. References

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